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Implementation of Computer Simulation to Streamline Satellite Motion Learning

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Abstract

This study aims to (1) produce a simulation-based satellite motion learning program, (2) describe the effectiveness of simulation-based satellite motion learning, (3) describe the level of effectiveness of satellite motion learning using simulation. The research method consists of; First, software engineering research, namely making satellite motion simulation learning programs based on simulation including: analysis, design, code, and testing. Second, research to see the effectiveness of simulation-based satellite motion simulation learning programs. Sampling using total sampling technique. Based on this, the researchers determined a sample of all Science Masters students in semesters 1 and 3 for the 2021/2022 school year as many as 40 people. The results showed that the satellite motion simulation learning program based on simulation was effective in learning, this can be seen from the N Gain value of 0.60 which is in the high or very effective category. Based on the simulation-based satellite motion learning questionnaire, it is effectively used for satellite motion material. It can be seen from the score obtained at 4.14 (from a scale of 1-5) in the effective category.

Keywords: *Effective, Implementation, Learning, Simulation, Two-Dimensional Motion*

A. Introduction

The 21st century education integrates Science, Technology, Engineering, and Mathematics (STEM)-based education. The STEM model integrates Science, Technology, Engineering, and Mathematics into a cohesive learning paradigm based on real-world applications. Currently, students are less interested in the STEM Model, one way to increase student interest through e-learning programs. Education using e-learning programs has emerged as a learning tool that involves direct and fun learning activities in a learning environment, so as to arouse students' interest and curiosity. An attractive learning environment motivates students to learn the skills and knowledge needed for them to achieve their goals when completing thesubjects they are interested in [1].

The implications of using information technology in making e-learning models generally stem from the learning conditions themselves. The conditions in question include physics teaching materials, facilities, learning models, students, and teachers who teach. The reality found in the field shows that there are students who are less interested in studying physics and find it difficult to understand the material, this is indicated by the low student physics learning outcomes. The understanding of a concept in physics learning is very important, for that animation that can show physical symptoms needs to be prioritized without ignoring other processes. Therefore, ideal e-learning must be able to function as a medium for presenting information in the form of text, graphics, simulations, animations, exercises, quantitative analysis, direct feedback, active, reactive, individual instructions according to the progress of learning. so as to provide the correct concept to students.

E-Learning can include training, timely delivery of information and guidance from experts [2]. E-learning includes applications and processes that use various electronic media such as the Internet, Audio/Video Tape, Interactive TV and CD-ROMs to deliver learning material more flexibly [3]. E-Learning as the use of electronic technology to convey, support and enhance teaching, learning and assessment [4]. Another opinion states that E-Learning is part of distance learning while on-Line learning is part of E-Learning (Manuel B. Garcia, 2017). The term E-Learning covers various forms of applications and processes such as computer-based learning, web-based learning, virtual classrooms, etc. The definition of E-learning is

defined as providing training and development to students/employees through various electronic media such as the internet, audio, video etc. [5].

E-learning programs make their users work, through knowledge identifying problems and argues that e-learning programs are motivating technologies because they are concrete, complex, and relate to deep human needs. Studies in the field of e-learning programs have reported that e-learning programs have a potential impact on student learning in various fields of study Physics, Mathematics, Engineering, Informatics and others and personal development including cognitive, meta-cognitive and social skills, such as: research skills, creative thinking, decision making, problem solving, communication and invention skills are all 21st century skills.

In learning, intrinsic motivation should be optimally developed so that student learning effectiveness can be achieved, because this motivation comes from within the student, so that psychologically the driving force is relatively stable and pure. To develop this motivation, E-Learning must be able to present/create a meaningful, complete and effective learning process. Students are said to be very effective in learning if the NGain value is ≥ 0.7 [6].

Besides that, research shows that online classes tend to be successful if they are based on pedagogical knowledge and the preparation of the correct teaching materials. E-learning learning allows students to freely study independently, easily understand the abstract, and cando virtual practicum [7]. Physics learning becomes enjoyable for students when it is packaged with good and correct simulations and animations [8]. The use of computer simulations can create meaningful learning, efficient learning management, and effective student administration

Based on the known literature, to change conventional learning to a multimedia learning system equipped with simulations it is necessary to create an interesting learning atmosphere with good substance so that the planting of the correct concepts can be carried out. E-learning must be able to "concretize" abstract concepts so that they are easily understood by students, this can be realized with the help of computer simulations. Specifically, the study in this research is how to develop and implement a satellite motion simulation program to make satellite motion learning effective.

B. Research Methods

This type of research consists of software engineering research and educational research. Software engineering research was carried out in the form of direct experimental research, aiming to simulate satellite motion. After software engineering research, then continued with educational research. Satellite motion simulations are used as media and teaching materials in satellite motion learning. Software engineering research and educational research were carried out at S2 IPA FKIP UNIB Bengkulu from May to September 2021. The tools used in this simulation consisted of a computer, a flat table, and software for learning programs. A computer that has loaded a simulation program written using Macromedia software. Furthermore, various satellite motion maneuvers were carried out. In the motion of the satellite, a large change is made to the radius of the satellite's trajectory so that the impact on the speed of the satellite's motion will be seen.

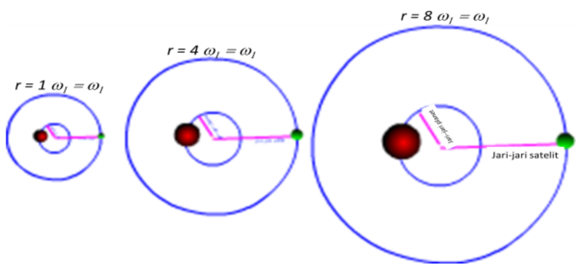

Figure 1. Finger 2, 4 and 8 Satellite Motion Simulation

Characteristics of Satellite Motion Simulation

Simulation is a training method that demonstrates something in an artificial form that is similar to the real situation (Ministry of National Education 2005). Simulation is a way of duplicating or describing the features, appearance, and characteristics of a real system [9]. The simulation method is to move a real situation into the study room because of the difficulty in practicing in a real situation [10].

Satellite motion is the movement of an object (satellite) that surrounds the planet with a circular or elliptical trajectory. In its movement, the satellite is affected (pulled) by the gravitational force of the planet it surrounds, so that the satellite remains in its position (its trajectory) the satellite must have a force that opposes the planet's gravitational force, namely the centrifugal force whose direction is opposite to the direction of the planet's gravitational force. If the gravitational force exerted by the planet on the satellite (GMm/R+r)2 is equal to the centrifugal force exerted by the satellite (mw2r), then the satellite's trajectory will be stable. M is the mass of the planet and m is the mass of the satellite, if M is much greater than m, then the distance from the center of mass from m is much greater than the distance from the center of mass M, so that r is much greater than R. Because Mw2.R=mw2r, and GMm/ (R+r)2 = mw2. R, then GMm = mw2. r. (R+ r) 2, because R<<r then GM = w2. r3. If w = 2/T then GM = 42.r3/T2 or GM = 4v/r, this means that the radius of the satellite track (r) is directly proportional to the linear speed of the satellite (v).

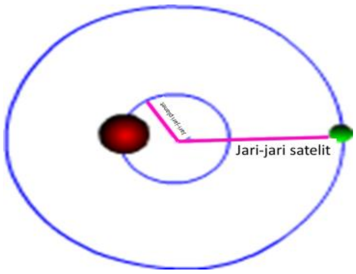

Figure 2. Satellite motion simulation image

Implementation in education

Implementation in educational research, satellite motion simulation is used as a medium and material. The research design is presented in Table 1.

Table 1. Research Design

Pre-test	Treatment	Post-test
O_1	X	O_2

Information

X: Learning Simulation of bullet motion and satellite motion

O1: Pre-test (pre-test)

O2: Final Test (post-test)

The research subjects used 40 students of Masters in Science Semesters 1 and 3 for the 2021/2022 school year

Data collection.

The test: the test given aims to determine the effectiveness of using the Computer Simulation Based Physics Learning Program in Physics Learning. The test questions are adjusted to the competencies desired in learning. This study uses a matter of 30 items.

Questionnaire: Satellite motion learning program based on computer simulation, distributed to all samples for study and each sample/research subject is required to provide a qualitative and quantitative assessment through a questionnaire regarding the role of computer simulation-based physics learning program to streamline student learning. The questionnaire consists of 40 statements, in each statement there are 5 choices with the following conditions

Table 2. Selection criteria and scores on the questionnaire

No	Option	Score	Category
1	Strongly agree	5	A
2	Agree	4	B
3	Simply agree	3	C
4	Don't agree	2	D
5	Strongly disagree	1	E

Processing data

Data on student learning outcomes consist of pretest and posttest results, then processed with the formula,

$$N_{gain} = \frac{(X_2 - X_1)}{(X_3 - X_1)}$$

The magnitude of x = pretest score, x2 = posttest score and x3 = maximum score. Questionnaire data to determine the effectiveness of learning used the following criteria

Table 3. Kriteria Efektivitas Pembelajaran Fisika Berbasiskan Simulasi Komputer

No	Score	Category	Quality
1	5	A	Very good
2	4	B	Good
3	3	C	Currently
4	2	D	Not enough
5	1	E	Bad

Data analysis

To test the effectiveness of learning using the Computer Simulation-Based Physics Learning Program, manual calculations are used, namely the N-Gain effectiveness formula as follows. N-Gain = posttest score – initial ability test score maximum score – initial ability test score [11]; [12]. N-Gain = Normalized Gain Pretest = Initial value of learning Posttest = Final value of learning. Computer Simulation Based Physics Learning Program is said to be effectively used in physics learning if the results of the student post-test are greater than the results of the pre-test (X2 > X1) and the number of students who score ≥70 ≥ 80%. Meanwhile, to determine the level of effectiveness of learning physics, the N gain formula is used, namely the comparison between the difference between the posttest and pretest with the difference in the maximum and pretest scores which is formulated as follows

$$N_{gain} = \frac{(X_2 - X_1)}{(X_3 - X_1)}$$ [13].

The magnitudes of X1, X2, X3 respectively are pre-test scores, post-test scores and maximum scores, Ngain's numbers range from 0 to 1, to determine the effectiveness of the use of simulation-based physics learning programs the following criteria are used

Table 4. Gain Index Criteria

No	Effectiveness Level	N_{gain}	Category
1	Very effective	≥ 0,70	High
2	Effective	0,30 - 0,70	Moderate
3	Effective enough	0,30	Low

Computer simulation-based physics learning program to determine the effectiveness of learning is also obtained through a questionnaire with the following criteria

Table 5. Criteria for the effectiveness of Computer Simulation-based Physics Learning

No	Criteria	Quality	Category
1	4,50 – 5,00	A	Very Effective
2	3,51 – 4,50	B	Effective
3	2,51 – 3,50	C	Less Effective
4	1,51 – 2,50	D	Ineffective
5	< 1,5	E	Very Ineffective

The score obtained is then processed with SPSS.

C. Results and Discussion

Satellite motion simulation

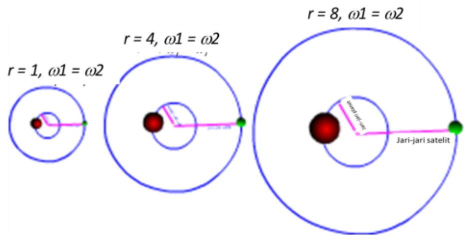

Figure 3. Satellite motion simulation for radii 2, 4 and 8

Learning module

After analysis, design, code, and testing, learning modules are obtained consisting of Teaching Materials Modules, Demo Modules, Analysis Modules, Examination Modules, Practice Test Modules, Problem Answers Modules, and Program Help Modules in Practice.

Teaching Materials Module, this module contains information about teaching materials. For interactivity systems with students using buttons. The presentation of the material is equipped with questions, which function to invite students to have a virtual dialogue, as well as provide answers to problems

Figure 4. Material screenshots

Demo Module, this module contains a program demo of the teaching materials discussed. For system interactivity with students, buttons are used. Students can enter input in the space provided, so that free interactivity is limited with users.

Figure 5. Screenshot of the Demo Module

Analysis Module, this module contains a quantitative analysis program in the form of calculation results of the questions/problems presented, also equipped with the necessary demos. System-student interactivity using buttons

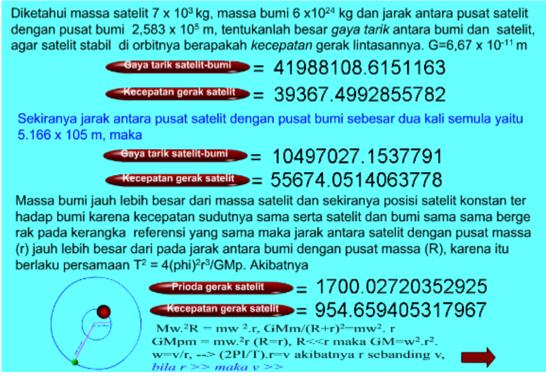

Figure 6. Screenshot of the Analysis Module

Examination module, exam module is a module that functions to test students' ability to teach materials. In the examination available options, b, c, and d. When the user clicks on one of them, the answer will be saved, after all the questions have been answered, a score will appear, according to the correct answer.

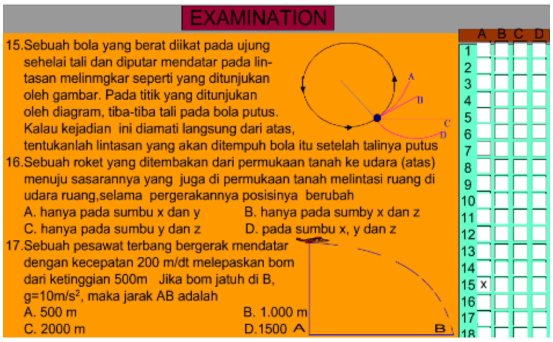

Figure 7. Examination Module screenshot

Practice Test Module, the practice test module is a module that functions to test students' abilities to teaching materials. In practice questions there are choices a, b, c, and d. When the user clicks on one of them, the answer is immediately known, either true or false. For this reason, all items are related to choices provided with two kinds of results, false/true or true/false

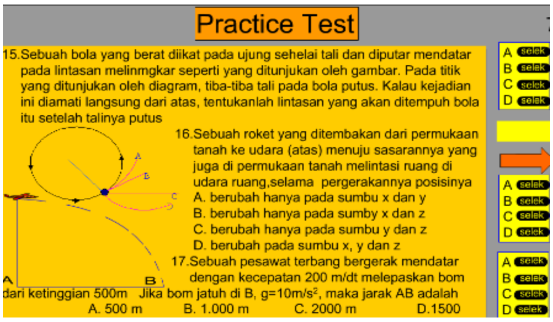

Figure 8. Screenshots of the Practice Test Module

Problem Answer Module, this module serves to provide answers to the problems presented in teaching materials, equipped with a quantitative analysis program, equipped with the necessary demos. For system interactivity with students, buttons are used.

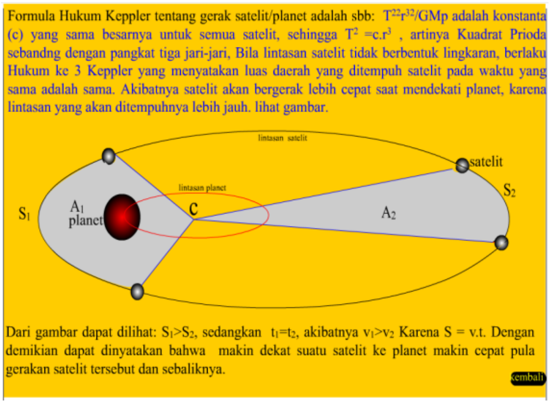

Figure 9. Screenshots of the Problem Answer Module

Program Assistance Module on Practice Tests, this module contains answers to questions on practice tests, in the form of a quantitative analytical program or narrative form, also equipped with the necessary demos. For system interactivity with students using buttons.

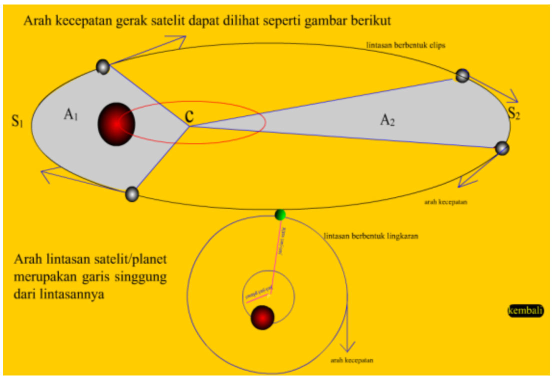

Figure 10. Screenshots of the Program Help module on Practice Test

Implementation in education

Implementation This research was carried out at S2 IPA FKIP UNIB Bengkulu in 2021. This study aims to determine the effectiveness of Satellite Motion Simulation as a learning medium to streamline Satellite Learning. To find out the effectiveness of the learning is done pretest and posttest. The pretest aims to determine students' initial understanding of the Satellite Motion material prior to learning. The posttest aims to determine students' understanding of the Satellite Motion material after receiving treatment in the form of learning using Satellite Motion Simulation. The pretest and posttest questions are the same, amounting to 30 multiple choice questions. The results of the pretest and posttest can be seen in table 6 and Figure 11

Table 6. Summary of pretest, posttest and questionnaire scores

No	NPM	Pre test	Post test	$(x_i - x)^2$	Pretes	Posttes	Questionnaire
1	A2L021001	30	77	0.25	27	87	4.6
2	A2L021002	37	80	99.0	27	77	4.3
3	A2L021003	40	77	8.7	23	90	4.5
4	A2L021004	37	77	8.7	37	90	4.2
5	A2L021005	47	80	8.7	30	90	4.4
6	A2L021006	27	60	8.7	30	90	4.4
7	A2L021007	30	80	8.7	27	90	3.4
8	A2L021008	40	80	0.25	27	87	3.8
9	A1L021009	27	77	8.7	23	90	3.9
10	A2L021010	30	83	49.7	27	80	4.5
11	A2L021011	30	73	0.25	27	87	4.2
12	A2L021012	27	77	99.6	23	77	4.4
13	A2L021013	33	77	8.7	37	90	3.8
14	A2L021014	13	67	8.7	30	90	3.9

No	NPM	Pre test	Post test	$(x_i - x)^2$	Pretes	Posttes	Questionnaire
15	A2L021015	27	60	8.7	30	90	4.5
16	A2L021016	27	70	8.7	20	90	3.5
17	A2L021017	27	53	8.7	20	90	3.3
18	A2L021018	37	67	16.4	33	83	4.6
19	A2L021019	50	80	16.4	30	83	4.3
20	A2L021020	20	60	8.7	37	90	4.5
21	A2L020001	40	83	8.7	30	90	4.2
22	A2L020002	27	73	49,7	30	80	4.4
23	A2L020003	30	77	8.7	20	90	4.4
24	A2L020004	30	77	8.7	20	90	3.4
25	A2L020005	27	67	0.25	33	87	3.8
26	A2L020006	33	60	0.25	30	87	3.9
27	A2L020007	13	70	0.25	13	87	4.5
28	A2L020008	27	63	8.7	17	90	4.2
29	A2L020009	27	67	49.7	27	80	4.4
30	A2L020010	27	80	0.25	40	87	3.8
31	A2L020011	37	60	99.0	17	77	3.9
32	A2L020012	50	77	8.7	30	90	4.5
33	A2L020013	20	80	8.7	43	90	3.5
34	A2L020014	30	77	8.7	20	90	3.3
35	A2L020015	37	77	8.7	27	90	4.6
36	A2L020016	40	80	8.7	27	90	4.3
37	A2L020017	37	60	16.4	23	83	4.5
38	A2L020018	47	80	16.4	37	83	4.2
39	A2L020019	27	80	8.7	30	90	4.4
40	A2L020020	30	77	8.7	30	90	4.4
	Jumlah	1272	2920	664.45	1109	3482	165.6
	Rata-rata	31.8	73	27.725		87.05	4.14
	Standar Dev.	8.55	8.10	6.5632		4.2904	0.398

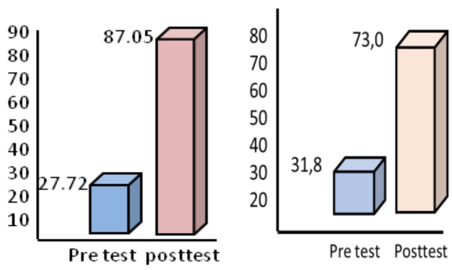

Figure 11. Graph of pretest and posttest

Based on table 3.1, the size of NGain can be calculated using the formula

N Gain = ((73.0-31.8))/((100 -31.8))=((41.2))/((68.2)) = 0.60

while the standard deviation is calculated using the formula

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Magnitude s = standard deviation, xi = i-value, x = mean score and n = sample size. Based on calculations using SPSS, the average score of the questionnaire/learning effectiveness is 4.14. While the standard deviation of post-test learning outcomes is 8.10, the standard deviation of the questionnaire/learning effectiveness is 0.398. The results of the study show that the Satellite Motion Simulation Learning Program is effectively used in learning, this can be seen from the NGain value of 0.60 which is in the high or very effective category. When using the questionnaire results indicators obtained a number of 4.14 is in the effective category.

Learning becomes effective and very effective using the Simulation-Based Satellite Motion Learning

Program due to the existence of an interactive multimedia system so that almost all the five senses are involved in absorbing and constructing knowledge. Learning using the Simulation-Based Satellite Motion Learning Program allows students to be free in learning, can be done anytime and anywhere and is equipped with animations and simulations that enable students to be motivated in learning.

The convenience and ease of use using the Simulation-Based Satellite Motion Learning Program helps students to feel at home in learning, so that the fun atmosphere adds to students' enthusiasm for learning. Besides that, the display presented by the Simulation-Based Satellite Motion Learning Program allows all types of student intelligence to be accommodated to grow and develop optimally, almost all student intelligence can be accommodated and realized in an e-learning learning program based on Satellite Simulation. In general it can be said that a Simulation-based Satellite Motion learning program can be carried out relatively easily, efficiently, effectively, individually, and inexpensively. The display presented by the Simulation-Based Satellite Motion Learning Program is complemented by animation, simulation, visualization, demos and analysis modules as well as training modules that allow students' misconceptions to reduce students' physics misconceptions. This is due to the effort to concretize things that have been considered abstract by students.

This finding is in line with other findings that use the concept of e-learning in learning in various countries. This finding is in line with other research findings including; The use of e-learning programs in learning can motivate students to learn [14]. the use of e-learning programs in learning can play a good role [15]. The use of e-learning programs in learning can significantly reduce student misconceptions [16].. The use of the e-learning program in learning can be a vehicle for the development of multiple intelligences [17]. Physics Learning Program Based on Center Feedback Simulation Press Stability Control of Walking Bipedal Robots is effectively used for material on balance and center of mass, this can be seen from the score obtained by 4.14 (from a scale of 1-5) is in the effective category.

D. Conclusion

The Simulation-Based Satellite Motion Learning Program is effective and very effective in learning Satellite Motion material, this can be seen from the N Gain value of 0.60 which is in the high or very effective category. Based on the Satellite Motion Learning Program questionnaire. Simulation Based is effectively used for Satellite Motion material, it can be seen from the score obtained at 4.14 (from a scale of 1-5) which is in the effective category.

Based on the acquisition of validity and reliability tests, it was found that the needs questionnaire used in collecting data had valid and reliable statement items. And the results of teacher interviews require learning media that are effective, interesting and can be accessed anytime and anywhere. The findings of the analysis are then presented needs response obtained from students and teachers strongly agreed to develop to boost students' grasp of topics, use animated video learning media on dynamic fluid material.

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